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Management of Large-Volume Subperiosteal Abscesses of the Orbit: Medical vs Surgical Outcomes

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Abstract

Objectives. To compare clinical variables and outcomes for children with subperiosteal abscesses of the orbit (SPAO) managed medically vs surgically to identify clinical prognosticators.

Study Design. Case series with chart review.

Setting. Tertiary children's academic institution.

Subjects and Methods. The study included 48 children between the age of 1 month and 14 years, with SPAO from 2003 to 2013. Variables included age, sex, physical examination findings, laboratory results, computed tomography (CT) findings, hospital length of stay, length of antibiotic therapy, and placement of a peripherally inserted central catheter (PICC). Intended methods for comparison were the Student *t* test for continuous variables and Fisher's exact test for categorical variables, and a forward stepwise multiple logistic regression.

Results. Thirty-two (67%) children were successfully treated with antibiotic therapy only, and 16 (33%) required surgery. Abscess volume, abscess width, and the presence of gaze restriction were statistically different between the 2 groups. A multivariate analysis found abscess volume as the only predictor for surgical intervention. A subgroup analysis including only patients with an abscess volume of $\geq$500 mm^3 (n = 26) was performed. Eleven patients were treated medically and 15 treated surgically, with the medical group having longer hospital stays (P = .048), duration of antibiotic therapy (P = .035), and higher incidence of PICC placement (P = .005).

Conclusions. This is the first study to report that abscess volume has clinical implications, as children with SPAO volume $\geq$500 mm^3 treated medically have longer inpatient admissions, antibiotic therapy durations, and PICC placement. When children present with an abscess $\geq$500 mm^3, early surgical intervention should be strongly considered, even in the absence of other surgical criteria, to shorten duration of hospitalization and accelerate clinical improvement.

Keywords

pediatric acute sinusitis, orbital subperiosteal abscess, medical vs surgical management, abscess volume

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A subperiosteal abscess of the orbit (SPAO) is a process in which purulence develops between the bony orbit and the periorbita, most commonly as a result of an infection of the ethmoid or frontal sinuses.[1] The incidence of SPAO as a complication of sinusitis for children with orbital complications is reported as 9% to 28%.[2,3] The potential anatomic pathways for spread of infection into the orbit from the sinus include the lamina papyracea, the ethmoidal artery foramina, and the anastomoses between the valve-less venous network draining the maxillary and ethmoid sinuses. Prompt and accurate diagnosis is critical in the treatment of a SPAO as there are potentially devastating consequences such as blindness, [4] cavernous sinus thrombosis,[5] meningitis, intracranial abscess, and death.

A SPAO was traditionally considered a surgical emergency that required immediate drainage; however, the management has evolved over the past few decades. The modern approach favors conservative medical management with intravenous (IV) antibiotics and close observation for patients without visual acuity changes or an increased intraocular pressure (IOP) >20, while assessing for worsening ophthalmologic findings or lack of improvement after 48 hours.[6] Despite this, there is still debate regarding

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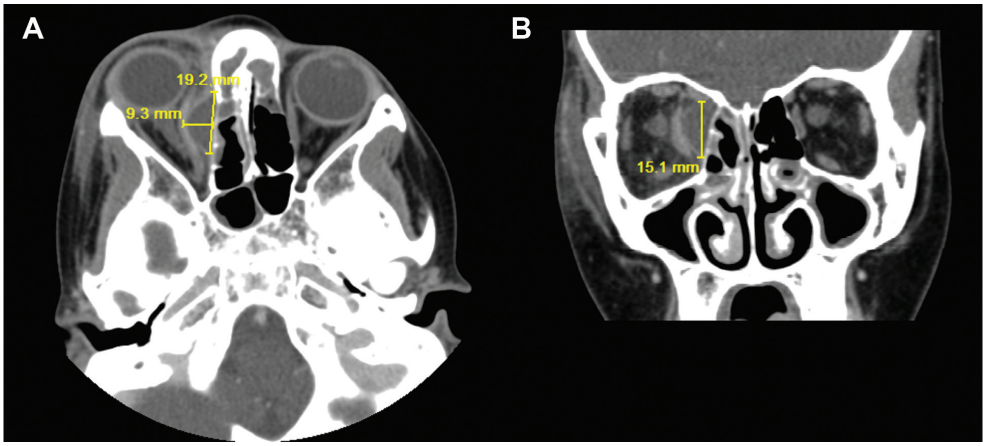

Figure 1. Computed tomography, sinus with contrast. Rim-enhancing subperiosteal abscess of 15.1 mm × 19.2 mm × 9.3 mm (volume of 2696 mm^3) in the medial position. (A) Axial. (B) Coronal.

clinical and imaging criteria that require upfront surgical management instead of an initial trial of medical therapy.

Previous studies have made varied recommendations for when to proceed with surgical intervention. Treatment failure has been defined as (1) development of visual loss or afferent pupillary defect,[4] (2) clinical deterioration after 48 hours,[7] or (3) no clinical improvement after 72 hours of treatment.[8]

Multiple studies have reported on abscess volume and found significant differences between surgical and medical groups. Gavriel et al[9] reported a mean volume difference of 1.389 vs 0.486 mL, and Rahbar et al[10] indicated 1452 and 600 mm^3 between the surgical and medical groups, respectively. The Quintanilla-Dieck et al[11] study found that an abscess volume of 670 mm^3 was 93% predictive for surgery. Tabarino et al[12] reported that 100% of abscesses with >500 mm^3 needed surgical intervention. Both Gavriel et al[9] and Tabarino et al[12] recommend using abscess volume >500 mm^3 as a criterion for surgical intervention.

Abscess width has also been examined and reported as a criterion for surgery. Oxford and McClay[13] found an abscess width of ≥ 4 mm to be a determining factor for surgery, and Ryan et al[3] found abscesses <10 mm could be successfully treated medically.

The objective of this study is to compare clinical presentations and outcomes for patients with SPAO managed medically vs surgically.

Methods

A retrospective chart review was performed on patients treated at Rady Children's Hospital San Diego from March 2003 to March 2013. Institutional review board approval was obtained from University of California, San Diego and Rady Children's Hospital San Diego. Clinical parameters collected include patient age, sex, physical examination findings (presenting temperature, proptosis, chemosis, gaze restriction), clinical characteristics (type of surgery performed, hospital length of stay, length of antibiotic therapy, placement of a peripherally inserted central catheter [PICC]), and laboratory findings (white blood cell count thousand [TH]/μL [WBC] and C-reactive protein, mg/dL [CRP]).

Inclusion criteria were inpatient admission for acute sinusitis with periorbital complications, regardless of other comorbidities, and patients 18 years or younger. Exclusion criteria were no computed tomography (CT) scan available for review or no SPAO present on CT as determined by the reviewing radiologist.

A uniform institutional clinical pathway for SPAO management was used for all children admitted to the hospital with suspected SPAO. All patients received a complete head and neck examination and ophthalmologic examination, and in the absence of impaired visual acuity, or intraocular pressure >20mmHg were started on IV antibiotics and assessed closely for 48 hours for clinical signs of improvement. In the event of clinical deterioration, no clinical improvement after 48 hours, or radiographic findings indicative of a worsening abscess, patients were taken for surgery. Clinical improvement or deterioration was defined as changes in periorbital or orbital swelling, gaze restriction, fevers, lab trends, or imaging findings. Assessments were decided jointly by the involved teams, however the decision for surgical intervention was ultimately made by the Otolaryngology attending. All patients obtained CT scans either at outside facilities before transfer or in the emergency department prior to admission. Patients were not taken for surgery based solely on initial CT findings or abscess volume.

All patients were examined by an ophthalmologist assessing gaze restriction, chemosis, proptosis, and visual acuity. Due to heterogeneity of the documentation, the findings were not always quantified and therefore were generalized into categories. The visual acuity was noted as normal or abnormal. The degree of proptosis was recorded as present or absent. When assessing gaze restriction for the purpose of this study, it was noted as positive if any directional gaze restriction was present.

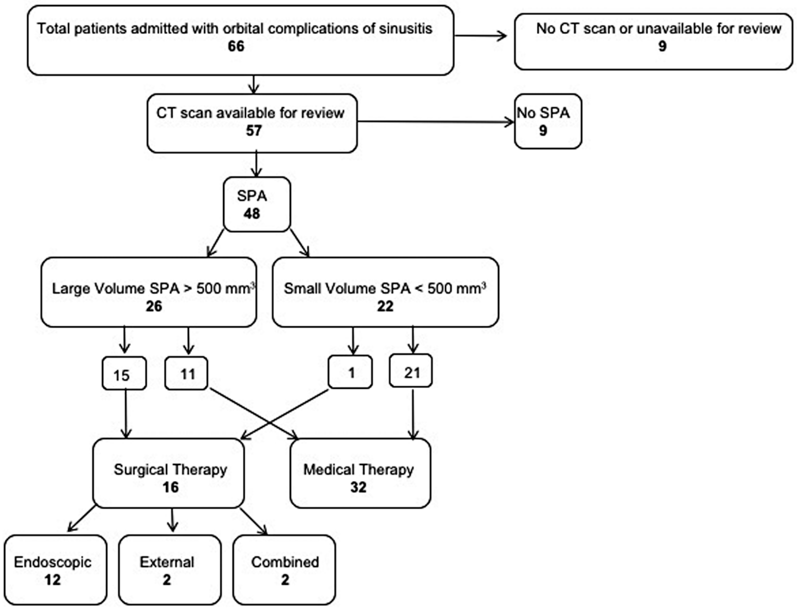

Figure 2. Flow diagram: patient selection criteria and management. CT, computed tomography; SPAO, subperiosteal abscess.

For objectivity, the CT studies were independently reviewed by a single radiologist (D.V.) who was blinded to treatment modality. The CTs were evaluated for characteristics of (1) presence, location, width, and dimensions of SPAO; (2) radiographic evidence of fat involvement, presence of air bubbles, and presence and number of extraocular muscles involved; and (3) any other unique findings or anatomic abnormalities (**Figure 1**).

To compare patient outcomes with similar disease burden, 2 different subgroups were created and analyzed separating patients based on abscess volume ($\geq$500 mm^3) or abscess width ($\geq$5 mm). These criteria were chosen based on the previously published data mentioned earlier as well as statistical trial and error of the data set. Comparisons were then made for length of hospital stay, length of antibiotic therapy, laboratory values, PICC placement, and other clinical variables. The decision for discharge was made by the admitting hospitalists with input from consulting specialists. There were no exact set criteria for when patients were discharged but were based on the patient's clinical state, laboratory findings, and response to antibiotic therapy.

The statistical tests used to analyze for differences between the 2 groups included 2-tailed Student *t* test normally distributed continuous variables, Mann-Whitney *U* for continuous variables not normally distributed, and a Fisher's exact 2-sided test for categorical variables. For all statistical tests, results were considered significant if $P < .05$ (2-tailed). A forward stepwise multiple logistic regression was performed using the covariates of age, presenting temperature, WBC, CRP, abscess width, abscess volume, proptosis, chemosis, and gaze restriction. Data analysis was performed using SPSS Statistics software, version 24 (SPSS, Inc, an IBM Company, Chicago, Illinois).

Results

The initial search identified 66 patients who were treated during the study period with a possible SPAO complication of sinusitis, ages 1 month to 14 years. Nine patients were excluded because they had an outside CT scan brought in by disc, and the actual images were not uploaded into our institutional PAX system at the time of admission and as a result were not available for the current blinded independent radiologic review required for this study. Another 9 patients were excluded as the scans were deemed by radiology review to not have an abscess, resulting in 48 patients (30 males and 18 females) being included in the study (**Figure 2**).

Thirty-two patients (67%) were treated with IV antibiotics alone (medical group), and 16 patients (33%) underwent surgical intervention in addition to IV antibiotics (surgical group). The clinical characteristics of the 2 groups are presented in **Table 1** and **Table 2**. There was a statistically significant difference in abscess width (3.9 mm vs 6.9 mm; P = .001), abscess volume (649 mm^3 vs 3077 mm^3; P = .002), and presence of gaze restriction (P = .034) between the medical and surgical groups, respectively.

The SPAO locations in the medical group included 18 medial, 7 superomedial, 6 inferomedial, and 1 superior. Locations in the surgical group included 9 medial, 2 superomedial, 3 inferomedial, 1 superior, and 1 superolateral. Twelve (75%) SPAOs were drained endoscopically, 2 (12.5%) with an external approach, and 2 (12.5%) with a combined external and endoscopic approach. The endoscopic surgical technique included addressing only the needed sinus to access the SPAO. In most cases, only an ethmoidectomy was needed, but in a few cases, a maxillary antrostomy was necessary. Often the abscess had eroded

Table 1. Nominal Variables of Entire Cohort, Medical vs Surgical Groups and Clinical Comparisons.

Entire Cohort	Medical Group (n = 32), No.	Surgical Group (n = 16), No.	*P* Value[a] (Fisher)	Odds Ratio
Sex				
Male	21	9	.55	1.5
Female	11	7		
Proptosis				
Yes	18	13	.116	3.3
No	14	3		
Chemosis				
Yes	6	5	.468	1.9
No	26	11		
Gaze restriction				
Yes	13	12	.034	4.3
No	19	4		
Air bubbles present				
Yes	2	2	.592	2.1
No	30	14		
PICC placement				
Yes	9	2	.293	
No	23	14		
Large volume $\geq$500 mm^3				
Yes	11	15	<.001	28.6
No	21	1		
Fat involved				
Yes	32	16	1	
No	0	0		
Large width $\geq$5 mm				
Yes	8	12	.002	9
No	24	4		
Extra-large width $\geq$10 mm				
Yes	0	3	.032	16.8
No	32	13		
<9 years old				
Yes	17	7	.76	1.45
No	15	9		
Medical complications				
Yes	8	1	.238	
No	24	15		

Abbreviation: PICC, peripherally inserted central catheter.
[a]Fisher's exact: 2-sided test.

through the lamina papyracea, but in some cases, opening the lamina papyracea was required. There were no surgical complications identified for any patients in the surgical group (**Table 3**).

In all cases, both the ophthalmology and otolaryngology teams were consulted. In the medical group, 17 (53%) were same-day consults, and 30 (93%) were within 1 day. In the surgical group, 11 (68%) were same-day consults, and 14 (87.5%) were within 1 day. There was no difference in consultation timing between the 2 groups (P = .316). Infectious disease (ID) consultations were obtained in 16 (50%) patients in the medical group and 7 (43%) in the surgical group.

In many cases, repeat CT scans were obtained. Nine (28%) in the medical group were for slow clinical improvements. Six (37.5%) patients in the surgical group had repeat imaging; 4 were 48 hours after admission for no clinical improvement that identified worsening abscesses. One was 3 days postsurgery secondary to symptom return, which identified a recurrent abscess necessitating repeat surgery, and 1 case was 4 days postsurgery for clinical plateau, but a revision procedure was not needed.

Antibiotic therapy was fairly standard for all patients and was initiated by the admitting pediatric team with suggestions by consultants, particularly ID in recalcitrant infections. In most cases (81%), patients were treated with a combination of IV clindamycin and ceftriaxone. In 4 cases, the patient received monotherapy with clindamycin or ceftriaxone, and in 4 cases, vancomycin was added. There was no difference in the antibiotics used between the medical and surgical groups (P = .116). Most patients were also started on a nasal regimen. Twelve (25%) received Afrin, saline, and a nasal steroid; 22 (45%) received Afrin and saline; 10 (21%) received Afrin only; and 4 (9%) did not have a nasal regimen.

For the subgroup analysis, patients were divided into a large-volume abscess subgroup ($\geq$500 mm^3, n = 26) (**Table 3**). Among this group, 11 of 26 patients did not meet surgical criteria. Some interesting differences were identified, as the medical group had a longer duration of antibiotic therapy (27.3 vs 16.3 days, P = .036) (**Figure 3A**) and hospital stay (6.7 vs 4.8 days, P = .035) (**Figure 3B**), as well as a higher incidence of PICC placement (P = .005). The same variables were examined in another subgroup analysis including only patients with an abscess width $\geq$5 mm, and there were no significant differences in age, abscess width, abscess volume, length of hospital stay, length of antibiotic therapy, or PICC placement.

A forward stepwise multiple logistic regression was performed using the covariates of age, presenting temperature, WBC, CRP, abscess width, abscess volume, proptosis, chemosis, and gaze restriction. Our model indicates abscess volume as the only predictor for surgical intervention.

Eight patients (25%) in the medical group had a medical complication including rash, diarrhea (not *Clostridium difficile*), serum sickness, and oral candidiasis. One patient (6%) in the surgical group had a medical complication, which was red man syndrome secondary to vancomycin use. The difference between groups was not significant (P = .238).

Cultures were obtained only in the 16 patients undergoing surgical intervention. Aerobic cultures included *Streptococcus viridans, Streptococcus pneumoniae*, methicillin-sensitive *Staphylococcus aureus*, coagulase-negative *Staphylococcus, Staphylococcus epidermidis, Eikennela corrodens*, and *Corynebacterium diphtheria.* Anaerobic cultures included *Propionibacterium acnes, Peptostreptococcus anaerobius*, and mixed oropharyngeal flora. There was no methicillin-resistant *S aureus* or other antibiotic resistant cultures, and as a result, no

Table 2. Continuous Variables of Entire Cohort, Medical vs Surgical Groups and Clinical Comparisons.

Entire Cohort	Medical Group (n = 32), Mean	Surgical Group (n = 16), Mean	*P* Value[a] (Student)
Age, y	6.8	7.7	.84
Presenting temperature, °C	37.7	35.4	.183
WBC, TH/μL	15.1	15.6	.824
CRP, mg/dL	6.7	10.9	.064
Abscess width, mm	3.9	6.9	.001
Abscess volume, mm^3	649	3077	.002
Length of hospital stay, d	4.9	4.8	.913
Length of antibiotic therapy, d	20.8	16.6	.217

Abbreviations: CRP, C-reactive protein; TH, thousand; WBC, white blood cell.
[a]Student *t* test: 2-tailed.

Table 3. Subgroup Analysis of Large-Volume Abscess (≥ 500 mm^3) Patients, Medical vs Surgical Groups and Clinical Comparisons.[a]

Characteristic	Medical Group (n = 11)	Surgical Group (n = 15)	*P* Value[b] (Student)
Age, y	6.7	8.02	.432
Presenting temperature, °C	37.5	37.8	.313
WBC, TH/μL	15.9	16.2	.92
CRP, mg/dL	6.5	11.5	.143
Abscess width, mm	6.2	7.3	.443
Abscess volume, mm^3	1498	3280	.179
Length of hospital stay, d	6.7	4.8	.035
Length of antibiotic therapy, d	27.3	16.3	.036[c]
PICC placement, No.			
Yes	6	1	.005[d]
No	5	14	

Abbreviations: CRP, C-reactive protein; PICC, peripherally inserted central catheter; TH, thousand; WBC, white blood cell.
[a]Values are presented as means unless otherwise indicated.
[b]Student *t* test: 2-tailed.
[c]Mann-Whitney *U* test.
[d]Fisher's exact test: 2-sided.

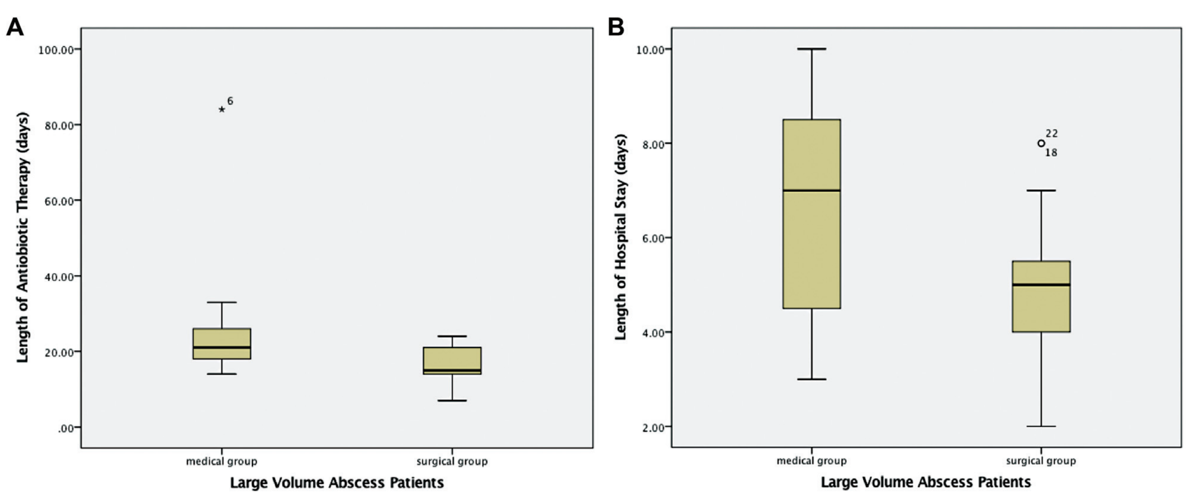

Figure 3. Boxplot of large-volume abscess (≥500 mm^3) subgroup. (A) The outlier is present at 84 days in the "length of antibiotic therapy" data. (B) Normal data distribution present in "length of hospital stay" variable.

PICCs were placed for need of a particular antibiotic to combat resistant organisms. Infections were polymicrobial in 7 (43%) cases, and there was no growth in 3 (19%) cases. Aerobic and anaerobic infections were compared for length of hospital stay, antibiotic duration, abscess volume, and PICC placement, and no significant differences were identified.

Discussion

This is the first study to identify that surgical management of a large-volume SPAO ($\geq$500 mm^3) results in shorter hospital stays, shorter antibiotic therapy duration, and less PICC line placement. The advantages of shorter hospital stays include decreased cost, less disruption to patient and family routines, decreased incidence of nosocomial infections,[14] and decreased psychiatric stress. Advantages of shorter antibiotic use with less PICC placement include decreased cost and side effects such as allergic reactions, weight gain,[15,16] resistance, super-infections, and any line-associated complications.

Abscess Volume

Abscess volume has been reported in some other studies using the simple ellipsoid formula of $4/3 \times \pi \times abc$, with a, b, and c corresponding to the radius of each dimension. In this study, we chose not to use the ellipsoid formula and use a simple multiple of the linear dimensions to allow for easier clinical application without the need to remember a formula and compute a calculation. For comparative purposes, a volume of 500 mm^3 calculated with the simple formula is equal to 261 mm^3 using the elliptical formula, or just over half of the volume.

Multiple studies have reported abscess volume as a criterion for surgical intervention, but the clinical outcomes between the 2 groups were not assessed or reported. The Gavriel et al[9] study strongly suggested an abscess volume $>$500 mm^3 (ellipsoid formula) for surgery. Rahbar et al[10] found a difference in abscess volume (simple formula) but did not have any recommendations based on abscess volume. Tabarino et al[12] reported that all abscesses with volume $>$500 mm^3 (ellipsoid formula) or 5% of the volume of the orbit were managed surgically.

Patient Age

Prior studies have suggested that older children are less likely to respond to medication alone. Published in 1974, the Welsh and Welsh study[17] reported that all patients aged 9 years or younger with SPAO had complete resolution without surgery. Garcia and Harris[8] reported that 27 of 29 patients younger than 9 years observed for medical therapy had SPAO that resolved without surgical intervention. They concluded that SPAO in patients younger than 9 years without other surgical criteria is likely to resolve without surgery.

In our study, no statistical difference in age was identified between the medical and surgical groups (6.8 and 7.7 years, P = .484) (see **Table 2**) and was not a predictor for surgical intervention. This was true with the large-volume abscess subgroup as well (P = .432). Based on the above-mentioned studies, the data in this study were analyzed using age 9 years as a parameter. When separating the patients by $<$9 (n = 24) vs $\geq$9 (n = 24), there were no differences in medical vs surgical management (P = .76). Surgery was performed in 7 of 24 in the $<$9 group and 9 of 24 in the $\geq$9 group (**Table 1**).

Laboratory Findings

In this study, there were no differences in presenting WBC (P = .824) or CRP (P = .064). The WBC finding is consistent with other studies[3,17] showing no significant differences between medical and surgical groups. In our experience, the trend of daily CRP is valuable and is likely to help as part of the big picture in determining clinical improvement with a decreasing value being reassuring.

PICC Placement

The purpose of PICC placement is multifold, but for our patient population in this study, it has allowed for earlier discharge with outpatient administration of IV antibiotics when extended courses were deemed necessary. Although more cost-effective than inpatient stay, there is still significant expense associated with PICC placement with the cost of insertion as well as the need for frequent home care nursing visits for antibiotic administration and catheter care. PICCs also have associated complications, including central line–associated bloodstream infections and deep venous thrombosis.

In our series, fortunately there were no reported cases of PICC line complications. However, the potential risk still exists, and surgical intervention in the large-volume abscesses was significant for lowering the chance of PICC line placement. The decreased placement of PICCs in the surgical group generally signifies that large abscesses addressed surgically had a more rapid response and infection resolution.

There are no widely accepted criteria for when to place a PICC, and at our institution, the decision is made by the ID consultants, and according to them, the general criteria considered when making the decision of PICC placement are disease severity based on clinical and laboratory findings, as well as the clinical response to antibiotics. Infections having a slower response were more likely to need extended IV therapy and therefore PICC placement.

Study Limitations

Study limitations include the retrospective nature and its associated biases and shortcomings. Additional limitations are the lack of specific measurements from the ophthalmologic examinations, including intraocular pressure, degree of proptosis, and severity of extraocular movement restrictions. Also, multiple surgeons rather than a single surgeon were involved in the decision-making process, which is somewhat subjective depending on the surgeon's comfort level and threshold for intervention. However, this may make our result more generalizable.

Conclusion

In this study, we have demonstrated that SPAO, including the larger volume ones, may be successfully managed with either medical or surgical therapies. The only significant predictable differences between the medical and surgical groups were abscess volume, abscess width, and gaze restriction. The multiple logistic regression found abscess volume as the only predictor for surgical intervention.

Abscess volume was found to have clinical implications as children with a SPAO volume $\geq$500 mm^3 treated with IV therapy only had longer inpatient admissions, antibiotic therapy durations, and PICC placement compared with patients undergoing surgical drainage. Most SPAOs were addressed with an endoscopic approach, which is safe and well tolerated. When children present with an abscess $\geq$500 mm^3, early surgical intervention should be strongly considered over medical treatment, even in the absence of other surgical criteria, to shorten duration of hospitalization and to accelerate clinical improvement.

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Author Contributions

Javan Nation, conception and design of the work; acquisition, analysis, and interpretation of data for the work; revising it critically for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; **Alexis Lopez**, conception and design of the work; acquisition, analysis, and interpretation of data for the work; revising it critically for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; **Nancy Grover**, conception and design of the work; acquisition, analysis, and interpretation of data for the work; revising it critically for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; **Daniela Carvalho**, conception and design of the work; acquisition, analysis, and interpretation of data for the work; revising it critically for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; **Daniel Vinocur**, conception and design of the work; acquisition, analysis, and interpretation of data for the work; revising it critically for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; **Wen Jiang**, conception and design of the work; acquisition, analysis, and interpretation of data; manuscript preparation; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Disclosures

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